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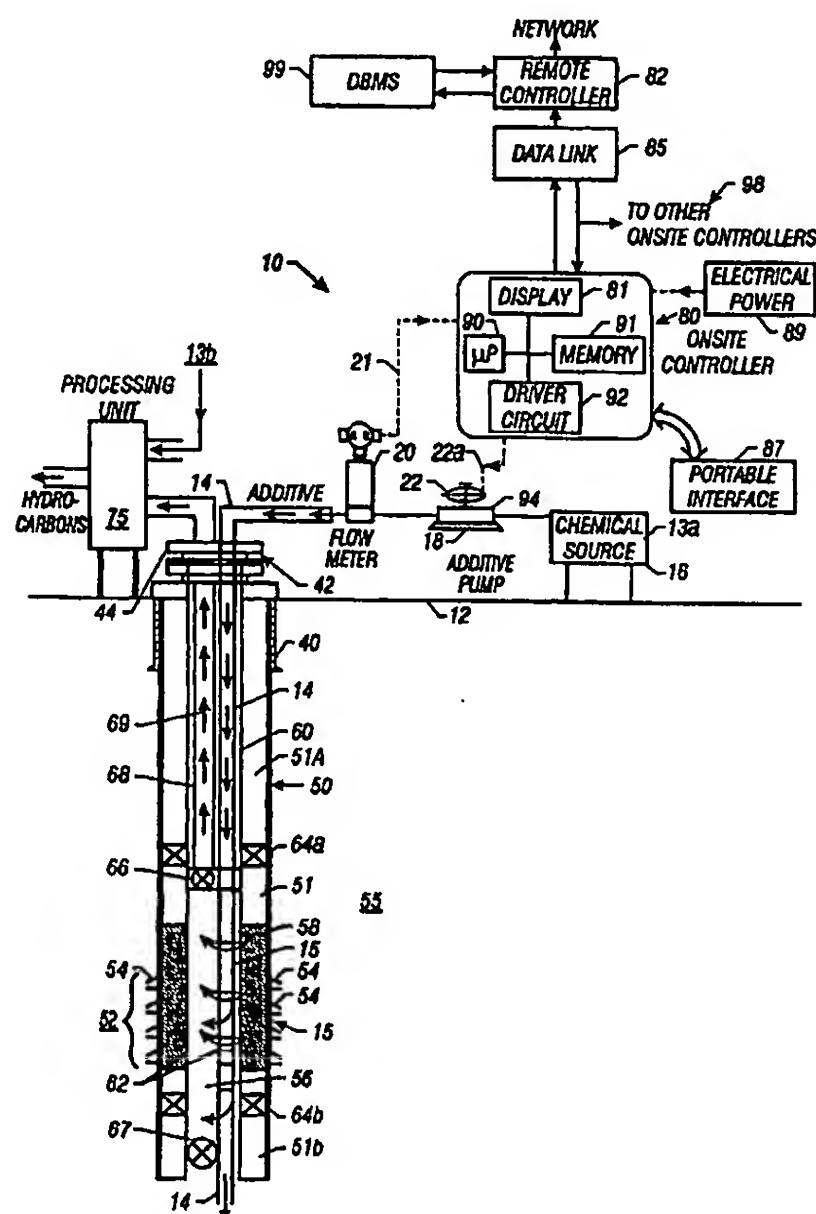
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(54) Title: CLOSED LOOP CHEMICAL INJECTION AND MONITORING SYSTEM FOR OILFIELD OPERATIONS

(57) Abstract

A system is provided that monitors at the wellsite injection of additives into formation fluids recovered through well bores and controls the supply of such additives from remote locations. A pump supplies the selected additive from a source at the wellsite into the wellbore via a suitable supply line. A flow meter in the supply line measures the flow rate of the additive through the supply line and generates signals representative of the flow rate. A controller at the wellsite determines the flow rate from the flow meter signals and in response thereto controls the pump to control the flow rate of the additive to the well. The wellsite controller interfaces with a suitable two-way communication link and transmits signals and data representative of the flow rate and other parameters to a second remote controller. The remote controller transmits command signals to the wellsite controller representative of any change desired for the flow rate. The wellsite controller is microprocessor based and may be programmed at the wellsite or by the remote controller to adjust the flow rate. The system of the present invention may be configured for multiple wells, with each well having a separate wellsite controller or a common wellsite controller.



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CLOSED LOOP CHEMICAL INJECTION AND MONITORING SYSTEM FOR OILFIELD OPERATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 This invention relates generally to oilfield operations and more particularly to a remotely/network-controlled chemical injection system for injecting precise amounts of additives or chemicals into wellbores, wellsite hydrocarbon processing units, pipelines, and chemical processing units.

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2. Background of the Art

 A variety of chemicals (also referred to herein as "additives") are often introduced into producing wells, wellsite hydrocarbon processing units, oil and gas pipelines and chemical processing units to control, among other things, corrosion, scale, paraffin, emulsion, hydrates, asphaltenes and formation of other harmful chemicals. In oilfield production wells, chemicals are usually injected through a tubing (also referred to herein as "conductor line") that is run from the surface to a

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known depth. Chemicals are introduced in connection with electrical submersible pumps (as shown for example in U.S. Patent No. 4,582,131 which is assigned to the assignee hereof and incorporated herein by reference) or through an auxiliary tubing associated with a power cable
5 used with the electrical submersible pump (such as shown in U.S. Patent No. 5,528,824 (assigned to the assignee hereof and incorporated herein by reference). Injection of chemicals into fluid treatment apparatus at the well site and pipelines carrying produced hydrocarbons is also known.

10 For oil well applications, a high pressure pump is typically used to inject a chemical into the well from a source thereof at the wellsite. The pump is usually set to operate continuously at a set speed or stroke length to control the amount of the injected chemical. A separate pump and an injector are typically used for each type of chemical. Manifolds
15 are sometimes used to inject chemicals into multiple wells, production wells are sometimes unmanned and are often located in remote areas or on substantially unmanned offshore platforms. A recent survey by Baker Hughes Incorporated of certain wellbores revealed that as many as thirty percent (30%) of the chemical pumping systems at unmanned locations
20 were either injecting incorrect amounts of the chemicals or were totally inoperative. Insufficient amounts of treatment chemicals can increase the

formation of corrosion, scale, paraffins, emulsion, hydrates etc., thereby reducing hydrocarbon production, the operating life of the wellbore equipment and the life of the wellbore itself, requiring expensive rework operations or even the abandonment of the wellbore. Excessive

5 corrosion in a pipeline, especially a subsea pipeline, can rupture the pipeline, contaminating the environment. Repairing subsea pipelines can be cost-prohibitive.

Commercially-used wellsite chemical injection apparatus usually

10 requires periodic manual inspection to determine whether the chemicals are being dispensed correctly. It is important and economically beneficial to have chemical injection systems which can supply precise amounts of chemicals and which systems are adapted to periodically or continuously monitor the actual amount of the treatment chemicals being dispensed,

15 determine the impact of the dispersed chemicals, vary the amount of dispersed chemicals as needed to maintain certain desired parameters of interest within their respective desired ranges or at their desired values, communicate necessary information with offsite locations and take actions based in response to commands received from such offsite

20 locations. The system should also include self-adjustment within defined parameters. Such a system should also be developed for monitoring and

controlling chemical injection into multiple wells in an oilfield or into multiple wells at a wellsite, such as an offshore production platform. Manual intervention at the wellsite of the system to set the system parameters and to address other operational requirements should also be
5 available.

The present invention addresses the above-noted problems and provides a chemical injection system which dispenses precise amounts of chemicals, monitors the dispensed amounts, communicates with remote
10 locations, takes corrective actions locally, and/or in response to commands received from the remote locations.

SUMMARY OF THE INVENTION

15 In one embodiment the present invention provides a wellsite chemical injection system that injects, monitors and controls the supply of chemicals into fluids recovered through wellbores, including with input from remote locations as appropriate. The system includes a pump that supplies, under pressure, a selected additive from a source thereof at the
20 wellsite into the wellbore via a suitable supply line. A flow meter in the supply line measures the flow rate of the additive and generates signals

representative of the flow rate. A controller at the wellsite (wellsite or onsite controller) determines from the flow meter signals the chemical flow rate, presents that rate on a display and controls the operation of the pump according to stored parameters in the controller and in response to
5 command signals received from a remote location. The controller interfaces with a suitable two-way communication link and transmits signals and data representative of the flow rate and other relevant information to a second controller at a remote location preferably via an EIA-232 or EIA-485 communication interface. The remote controller may
10 be a computer and may be used to transmit command signals to the wellsite controller representative of any change desired for the flow rate. The wellsite controller adjusts the flow rate of the additive to the wellbore to achieve the desired level of chemical additives.

15 The wellsite controller is preferably microprocessor-based system and can be programmed to adjust the flow rate automatically when the calculated flow rate is outside predetermined limits provided to the controller. The flow rate is increased when it falls below a lower limit and is decreased when it exceeds an upper limit.

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The system of the present invention may be configured for multiple wells at a wellsite, such as an offshore platform. In one embodiment, such a system includes a separate pump, a fluid line and an onsite controller for each well. Alternatively, a suitable common onsite controller may be provided to communicate with and to control multiple wellsite pumps via addressable signaling. A separate flow meter for each pump provides signals representative of the flow rate for its associated pump to the onsite common controller. The onsite controller may be programmed to display the flow rates in any order as well as other relevant information. The onsite controller at least periodically polls each flow meter and performs the above-described functions. The common onsite controller transmits the flow rates and other relevant or desired information for each pump to a remote controller. The common onsite controller controls the operation of each pump in accordance with the stored parameters for each such pump and in response to instructions received from the remote controller. If a common additive is used for a number of wells, a single additive source may be used. A single or common pump may also be used with a separate control valve in each supply line that is controlled by the controller to adjust their respective flow rates.

A suitable precision low-flow, flow meter is utilized to make precise measurements of the flow rate of the injected chemical. Any positive displacement-type flow meter, including a rotating flow meter, may also be used. The onsite controller is environmentally sealed and can operate
5 over a wide temperature range. The present system is adapted to port to a variety of software and communications protocols and may be retrofitted on the commonly used manual systems, existing process control systems, or through uniquely developed chemical management systems developed independently or concurrently.

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The chemical injection of the present invention may also utilize a mixer wherein different chemicals are mixed or combined at the wellsite and the combined mixture is injected by a common pump and metered by a common meter. The onsite controller controls the amounts of the
15 various chemicals into the mixer. The chemical injection system may further include a plurality of sensors downhole which provide signals representative of one or more parameters of interest relating to the characteristics of the produced fluid, such as the presence or formation of sulphites, paraffin, emulsion, scale, asphaltenes, hydrates, fluid flow
20 rates from various perforated zones, flow rates through downhole valves, downhole pressures and any other desired parameter. The system may

also include sensors or testers at the surface which provide information about the characteristics of the produced fluid. The measurements relating to these various parameters are provided to the wellsite controller which interacts with one or more models or programs provided to the
5 controller or determines the amount of the various chemicals to be injected into the wellbore and/or into the surface fluid treatment unit and then causes the system to inject the correct amounts of such chemicals. In one aspect, the system continuously or periodically updates the models based on the various operating conditions and then controls the chemical
10 injection in response to the updated models. This provides a closed-loop system wherein static or dynamic models may be utilized to monitor and control the chemical injection process.

The system of the present invention is equally applicable to
15 monitoring and control of chemical injection into oil and gas pipelines, wellsite fluid treatment units, and refining and petrochemical chemical treatment applications.

BRIEF DESCRIPTION OF THE DRAWINGS

For a detailed understanding of the present invention, reference should be made to the following detailed description of the preferred
5 embodiments, taken in conjunction with the accompanying drawings, in which like elements have been given like numerals, wherein:

Figure 1 is a schematic illustration of a chemical injection and monitoring system according to one embodiment of the present invention.

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Figure 1A shows an alternative manner for controlling the operation of the chemical additive pump.

Figure 1B shows a circuit for providing a measure of manual
15 control of the controller for additive injection pump 22.

Figure 2 shows a functional diagram depicting one embodiment of the system for controlling and monitoring the injection of additives into multiple wellbores, utilizing a central controller on an addressable control
20 bus.

Figure 3 is a schematic illustration of a wellsite chemical injection system which responds to in-situ measurements of downhole and surface parameters of interests according to one embodiment of the present invention.

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DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 is a schematic diagram of a wellsite chemical injection system **10** according to one embodiment of the present invention. The system **10**, in one aspect, is shown as injecting and monitoring of chemicals **13a** into a wellbore **50** and, in another aspect, injecting and monitoring of chemicals **13b** into a wellsite surface treatment or processing unit **75**. The wellbore **50** is shown to be a production well using typical completion equipment. The wellbore **50** has a production zone **52** which includes multiple perforations **54** through the formation **55**. Formation fluid **56** enters a production tubing **60** in the well **50** via perforations **54** and passages **62**. A screen **58** in the annulus **51** between the production tubing **60** and the formation **55** prevents the flow of solids into the production tubing **60** and also reduces the velocity of the formation fluid entering into the production tubing **60** to acceptable levels. An upper packer **64a** above the perforations **54** and a lower

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packer **64b** in the annulus **51** respectively isolate the production zone **52** from the annulus **51a** above and annulus **51b** below the production zone **52**. A flow control valve **66** in the production tubing **60** can be used to control the fluid flow to the surface **12**. A flow control valve **67** may be placed in the production tubing **62** below the perforations **54** to control fluid flow from any production zone below the production zone **52**.

A smaller diameter tubing, such as tubing **68**, may be used to carry the fluid from the production zones to the surface. A production well usually includes a casing **40** near the surface and wellhead equipment **42** over the wellbore. The wellhead equipment generally includes a blow-out preventor stack **44** and passages for supplying fluids into the wellbore **50**. Valves (not shown) are provided to control fluid flow to the surface **12**. Wellhead equipment **42** and production well equipment, such as shown in the production well **60**, are well known and thus are not described in greater detail.

Referring back to **Figure 1**, in one aspect of the present invention, the desired chemical **13a** from a source **16** thereof is injected into the wellbore **50** via an injection line **14** by a suitable pump, such as a positive displacement pump **18** ("additive pump"). The chemical **13a** flows

through the line 14 and discharges into the production tubing 60 near the production zone 52 via inlets or passages 15. The same or different injection lines may be used to supply chemicals to different production zones. In Figure 1, line 14 is shown extending to a production zone
5 below the zone 52. Separate injection lines allow injection of different additives at different well depths. The same also holds for injection of additives in pipelines or surface processing facilities.

A suitable high-precision, low-flow, flow meter 20 (such as gear-
10 type meter or a nutating meter), measures the flow rate through line 14 and provides signals representative of the flow rate. The pump 18 is operated by a suitable device 22 such as a motor. The stroke of the pump 18 defines fluid volume output per stroke. The pump stroke and/or the pump speed are controlled, e.g., by a 4 - 20 milliamperes control
15 signal to control the output of the pump 18. The control of air supply controls a pneumatic pump.

In the present invention, an onsite controller 80 controls the operation of the pump 18, either utilizing programs stored in a memory
20 91 associated with the wellsite controller 80 and/or instructions provided to the wellsite controller 80 from a remote controller or processor 82.

The wellsite controller **80** preferably includes a microprocessor **90**, resident memory **91** which may include read only memories (ROM) for storing programs, tables and models, and random access memories (RAM) for storing data. The microprocessor **90**, utilizing signals from the flow meter **20** received via line **21** and programs stored in the memory **91** determining the flow rate of the additive and displays such flow rate on the display **81**. The wellsite controller **80** can be programmed to alter the pump speed, pump stroke or air supply to deliver the desired amount of the chemical **13a**. The pump speed or stroke, as the case may be, is increased if the measured amount of the chemical injected is less than the desired amount and decreased if the injected amount is greater than the desired amount. The onsite controller **80** also includes circuits and programs, generally designated by numeral **92** to provide interface with the onsite display **81** and to perform other functions.

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The onsite controller **80** polls, at least periodically, the flow meter **20** and determines therefrom the chemical injection flow rate and generates data/signals which are transmitted to a remote controller **82** via a data link **85**. Any suitable two-way data link **85** may be utilized. There also may be a data management system associated with the remote controller. Such data links may include, among others, telephone

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modems, radio frequency transmission, microwave transmission and satellites utilizing either EIA-232 or EIA-485 communications protocols (this allows the use of commercially available off-the-shelf equipment). The remote controller **82** is preferably a computer-based system and can
5 transmit command signals to the controller **80** via the link **85**. The remote controller **82** is provided with models/programs and can be operated manually and/or automatically to determine the desired amount of the additive to be injected. If the desired amount differs from the measured amount, it sends corresponding command signals to the
10 wellsite controller **80**. The wellsite controller **80** receives the command signals and adjusts the flow rate of the chemical **13a** into the well **50** accordingly. The remote controller **82** can also receive signals or information from other sources and utilize that information for additive pump control.

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The onsite controller **80** preferably includes protocols so that the flow meter **20**, pump control device **22**, and data links **85** made by different manufacturers can be utilized in the system **10**. In the oil industry, the analog output for pump control is typically configured for 0-
20 5 VDC or 4-20 milliampere (mA) signal. In one mode, the wellsite controller **80** can be programmed to operate for such output. This allows

for the system **10** to be used with existing pump controllers. A suitable source of electrical power source **89**, e.g., a solar-powered DC or AC power unit, or an onsite generator provides power to the controller **80**, converter **83** and other electrical circuit elements. The wellsite controller **80** is also provided with a display **81** that displays the flow rates of the individual flow meters. The display **81** may be scrolled by an operator to view any of the flow meter readings or other relevant information. The display **81** is controllable either by a signal from the remote controller **82** or by a suitable portable interface device **87** at the well site, such as an infrared device or a key pad. This allows the operator at the wellsite to view the displayed data in the controller **80** non-intrusively without removing the protective casing of the controller.

Still referring to **Figure 1**, the produced fluid **69** received at the surface is processed by a treatment unit or processing unit **75**. The surface processing unit **75** may be of the type that processes the fluid **69** to remove solids and certain other materials such as hydrogen sulphide, or that processes the fluid **69** to produce semi-refined to refined products. In such systems, it is desired to periodically or continuously inject certain chemicals. A system, such as system **10** shown in **Figure 1** can be used for injecting and monitoring chemicals into the treatment unit **75**.

In addition to the flow rate signals 21 from the flow meter 20, the wellsite controller 80 may be configured to receive signals representative of other parameters, such as the rpm of the pump 18, or the motor 22 or the modulating frequency of a solenoid valve. In one mode of operation, the wellsite controller 80 periodically polls the meter 20 and automatically adjusts the pump controller 22 via an analog input 22a or alternatively via a digital signal of a solenoid controlled system (pneumatic pumps). The controller 80 also can be programmed to determine whether the pump output, as measured by the meter 20, corresponds to the level of signal 22a. This information can be used to determine the pump efficiency. It can also be an indication of a leak or another abnormality relating to the pump 18. Other sensors 94, such as vibration sensors, temperature sensors may be used to determine the physical condition of the pump 18. Sensors which determine properties of the wellbore fluid can provide information of the treatment effectiveness of the chemical being injected, which information can then be used to adjust the chemical flow rate as more fully described below in reference to Figure 3. The remote controller 82 may control multiple onsite controllers via a link 98. A data base management system 99 may be provided for the remote controller 82 for historical monitoring and management of data. The system 10 may further be adapted to communicate with other locations

via a network (such as the Internet) so that the operators can log into the database 99 and monitor and control chemical injection of any well associated with the system 10.

5 **Figure 1A** shows an alternative manner for controlling the additive pump. This configuration includes a control valve, such as a solenoid valve 102, in the supply line 106 from a source of fluid under pressure (not shown) for the pump controller 22. The controller 80 controls the operation of the valve via suitable control signals, such as digital signals,
10 provided to the valve 102 via line 104. The control of the valve 22 controls the speed or stroke of the pump 18 and thus the amount of the additive supplied to the wellbore 50. The valve control 102 may be modulated to control the output of the pump 18.

15 The automated modes of operation (both local and/or from the remote location) of the injection system 10 are described above. However, in some cases it is desirable to operate the control system 10 in a manual mode, such as by an operator at the wellsite. Manual control may be required to override the system because of malfunction of the
20 system or to repair parts of the system 10. **Figure 1B** shows a circuit 124 for manual control of the additive pump 18. The circuit 124 includes

a switch 120 associated with the controller (see Figure 1), which in a first or normal position (solid line 22b) allows the analog signal 22a from the controller to control the motor 22 and in the second position (dotted line 22c) allows the manual circuit 124 to control the motor 22. The

5 circuit 124, in one configuration, may include a current control circuit, such as a rheostat 126 that enables the operator to set the current at the desired value. In the preferred embodiment, the current range is set between 4 and 20 milliamperes, which is compatible with the current industry protocol. The wellsite controller is designed to interface with

10 manually-operated portable remote devices, such as infrared devices. This allows the operator to communicate with and control the operation of the system 10 at the well site, e.g., to calibrate the system, without disassembling the wellsite controller 80 unit. This operator may reset the allowable ranges for the flow rates and/or setting a value for the flow

15 rate.

As noted above, it is common to drill several wellbores from the same location. For example, it is common to drill 10-20 wellbores from a single offshore platform. After the wells are completed and producing,

20 a separate pump and meter are installed to inject additives into each such wellbore. Figure 2 shows a functional diagram depicting a system 200

for controlling and monitoring the injection of additives into multiple wellbores **202a-202m** according to one embodiment of the present invention. In the system configuration of **Figure 2**, a separate pump supplies an additive from a separate source to each of the wellbores

5 **202a-202m**. Pump **204a** supplies an additive from the source **206a**. Meter **208a** measures the flow rate of the additive into the wellbore **202a** and provides corresponding signals to a central wellsite controller **240**. The wellsite controller **240** in response to the flow meter signals and the programmed instructions or instructions from a remote controller **242**

10 controls the operation of pump control device or pump controller **210a** via a bus **241** using addressable signaling for the pump controller **210a**. Alternatively, the wellsite controller **240** may be connected to the pump controllers via a separate line. Furthermore, a plurality of wellsite controllers, one for each pump may be provided, wherein each such

15 controller communicating with the remote controller **242** via a suitable communication link as described above in reference to **Figure 1**. The wellsite controller **240** also receives signal from sensor **S1a** associated with pump **204a** via line **212a** and from sensor **S2a** associated with the pump controller **210a** via line **212a**. Such sensors may include rpm

20 sensor, vibration sensor or any other sensor that provides information about a parameter of interest of such devices. Additives to the wells

202b-202m are respectively supplied by pumps 204b-204m from sources 206b-206m. Pump controllers 210b-210m respectively control pumps 204b-204m while flow meters 208b-208m respectively measure flow rates to the wells 202b-202m. Lines 212b-212m and lines 214b-214m
5 respectively communicate signals from sensor S_{1b} - S_{1m} and S_{2b} - S_{2m} to the central controller 240. The controller 240 utilizes memory 246 for storing data in memory 244 for storing programs in the manner described above in reference to system 10 of Figure 1. A suitable two-way communication link 245 allows data and signals communication between
10 the central wellsite controller 240 and the remote controller 242. The individual controllers would communicate with the sensors, pump controllers and remote controller via suitable corresponding connections.

The central wellsite controller 240 controls each pump
15 independently. The controller 240 can be programmed to determine or evaluate the condition of each of the pumps 204a-204m from the sensor signals S_{1a} - S_{1m} and S_{2a} - S_{2m} . For example the controller 240 can be programmed to determine the vibration and rpm for each pump. This can provide information about the effectiveness of each such pump. The
20 controller 240 can be programmed to poll the flow rates and parameters of interest relating to each pump, perform desired computations at the

well site and then transmit the results to the remote controller **242** via the communication link **248**. The remote controller **242** may be programmed to determine any course of action from the received information and any other information available to it and transmit
5 corresponding command signals to the wellsite central controller **240**. Again, communication with a plurality of individual controllers could be done in a suitable corresponding manner.

Figure 3 is a schematic illustration of wellsite remotely-controllable
10 closed-loop chemical injection system **300** which responds to measurements of downhole and surface parameters of interest according to one embodiment of the present invention. Certain elements of the system **300** are common with the system **10** of Figure 1. For convenience, such common elements have been designated in Figure 3
15 with the same numerals as specified in Figure 1.

The well **50** in Figure 3 further includes a number of downhole sensors S_{3a} - S_{3m} for providing measurements relating to various downhole parameters. Sensor S_{3a} provide a measure of chemical characteristics of
20 the downhole fluid, which may include a measure of the paraffins, hydrates, sulphides, scale, asphaltenes, emulsion, etc. Other sensors and

devices S_{3m} may be provided to determine the fluid flow rate through perforations 54 or through one or more devices in the well 50. The signals from the sensors may be partially or fully processed downhole or may be sent uphole via signal/data lines 302 to a wellsite controller 340.

5 In the configuration of Figure 3, a common central control unit 340 is preferably utilized. The control unit is a microprocessor-based unit and includes necessary memory devices for storing programs and data and devices to communicate information with a remote control unit 342 via suitable communication link 342.

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The system 300 may include a mixer 310 for mixing or combining at the wellsite a plurality of chemical#1 - chemical#m stored in sources 313a-312m respectively. In some situations, it is desirable to transport certain chemicals in their component forms and mix them at the wellsite

15 for safety and environmental reasons. For example, the final or combined chemical may be toxic, although while the component parts may be non-toxic. Chemicals may be shipped in concentrated form and combined with diluents at the wellsite prior to injection into the well 50. In one embodiment of the present invention, chemicals to be combined, such as

20 chemicals chemical#1-chemical#m are metered into the mixer by associated pumps 314a-314m. Meters 316a-316m measure the

amounts of the chemicals from sources **312a-312m** and provide corresponding signals to the control unit **340**, which controls the pumps **314a-314m** to accurately dispense the desired amounts into the mixer **310**. A pump **318** pumps the combined chemicals from the mixer **310** into the well **50**, while the meter **320** measures the amount of the dispensed chemical and provides the measurement signals to the controller **340**. A second chemical required to be injected into the well **50** may be stored in the source **322**, from which source a pump **324** pumps the required amount of the chemical into the well. A meter **326** provides the actual amount of the chemical dispensed from the source **322** to the controller **340**, which in turn controls the pump **324** to dispense the correct amount.

The wellbore fluid reaching the surface may be tested on site with a testing unit **330**. The testing unit **330** provides measurements respecting the characteristics of the retrieved fluid to the central controller **340**. The central controller utilizing information from the downhole sensors S_{3a} - S_{3m} , the tester unit data and data from any other surface sensor (as described in reference to **Figure 1**) computes the

effectiveness of the chemicals being supplied to the well 50 and determine therefrom the correct amounts of the chemicals and then alters the amounts, if necessary, of the chemicals to the required levels.

5 The controller also provides the computed and/or raw data to the remote control unit 342 and takes corrective actions in response to any command signals received from the remote control unit 342. Thus, the system of the present invention at least periodically monitors the actual amounts of the various chemicals being dispensed, determines the
10 effectiveness of the dispensed chemicals, at least with respect to maintaining certain parameters of interest within their respective predetermined ranges, determines the health of the downhole equipment, such as the flow rates and corrosion, determines the amounts of the chemicals that would improve the effectiveness of the system and then
15 causes the system to dispense chemicals according to newly computed amounts. The models 344 may be dynamic models in that they are updated based on the sensor inputs.

 Thus, the system described in Figure 3 is a closed-loop, remotely
20 controllable chemical injection system. This system may be adapted for use with a hydrocarbon processing unit 75 at the wellsite or for a pipeline

carrying oil and gas. The chemical injection system of **Figure 3** is particularly useful for subsea pipelines. In oil and gas pipelines, it is particularly important to monitor the incipient formation of hydrates and take prompt corrective actions to prevent them from forming. The

5 system of the present invention can automatically take broad range of actions to assure proper flow of hydrocarbons through pipelines, which not only can avoid the formation of hydrates but also the formation of other harmful elements such as asphaltenes. Since the system **300** is closed loop in nature and responds to the in-situ measurements of the

10 characteristics of the treated fluid and the equipment in the fluid flow path, it can administer the optimum amounts of the various chemicals to the wellbore or pipeline to maintain the various parameters of interest within their respective limits or ranges, thereby, on the one hand, avoid excessive use of the chemicals, which can be very expensive and, on the

15 other hand, take prompt corrective action by altering the amounts of the injected chemicals to avoid formation of harmful elements.

While foregoing disclosure is directed to the preferred embodiments of the invention, various modifications will be apparent to those skilled in

20 the art. It is intended that all variations within the scope and spirit of the appended claims be embraced by the foregoing disclosure.

WHAT IS CLAIMED IS:

- 1 1. A system for monitoring and controlling supply of an additive
2 introduced into formation fluid recovered through a wellbore, comprising:
- 3 (a) a flow control device for supplying a selected additive from
4 a source thereof at wellsite to the formation fluid;
- 5 (b) a flow measuring device for providing a signal representative
6 of flow rate of the selected additive supplied to said
7 formation fluid;
- 8 (c) a first onsite controller receiving the signals from the flow
9 measuring device and determining therefrom the flow rate,
10 said first onsite controller transmitting signals representative
11 of the flow rate to a remote location; and
- 12 (d) a second remote controller at said remote location receiving
13 signals transmitted by said first controller and in response
14 thereto transmitting command signals to said first controller
15 representative of a desired change in the flow rate of the
16 selected additive;
- 17 wherein the first onsite controller causes the flow control device
18 to change the flow rate of the selected additive in response to the
19 command signals.

20 2. The system of claim 1, wherein said first onsite controller includes
21 a display that displays at least the flow rate of the selected additive
22 supplied to the formation fluid.

1 3. The system of claim 1, wherein the additive is supplied to one of
2 (a) a selected location in the wellbore or (b) a hydrocarbon processing unit
3 processing the formation fluid at the wellsite.

1 4. The system of claim 1, wherein the flow measuring device is a
2 positive displacement flow meter.

1 5. The system of claim 1 further comprising a program associated
2 with said first onsite controller that enables the onsite controller to
3 perform a plurality of on-board functions.

1 6. The system of claim 5, wherein said plurality of functions includes
2 at least one of (i) determining the difference between the amount of
3 additive introduced and a predetermined desired amount, (ii) calibration
4 of the flow control device, and (iii) periodic polling of said flow measuring
5 device.

1 7. The system of claim 1, wherein said first onsite controller is
2 programmable (i) at the wellsite or, (ii) by said second remote controller.

1 8. The system of claim 1 further comprising a data base management
2 system associated with said second remote controller.

1 9. The system of claim 8, wherein said second remote controller is
2 adapted to communicate with a plurality of computers over a network.

1 10. The system of claim 1, wherein the flow control device is one of
2 (ii) an electric pump, or (ii) a pneumatic pump.

1 11. The system of claim 1 further including at least one sensor
2 providing a measure of a characteristic of said formation fluid.

3 12. The system of claim 11, wherein said system alters the supply of
4 said selected additive in response to said measured characteristic.

1 13. A system for monitoring and controlling supply of additives to a
2 plurality of wells, said system further comprising:

- 3 (a) a supply line and a flow control device associated with each
4 of said plurality of wells;
- 5 (b) a flow measuring device in each said supply line measuring
6 a parameter indicative of the flow rate of an additive
7 supplied to a corresponding well, each said flow measuring
8 device generating signals indicative of a flow rate of the
9 additive supplied to its corresponding well; and
- 10 (c) a first onsite controller receives signals from each of the
11 flow measuring devices and transmits signals representative
12 of the flow rate for each well to a second remote controller
13 which in response to the signals transmitted by said first
14 onsite controller transmits to said first onsite controller
15 command signals representative of a desired change in the
16 flow rate of the additives supplied to each said well.

1 14. The system of claim 13, wherein the additive is injected into each
2 said well at predetermined depths.

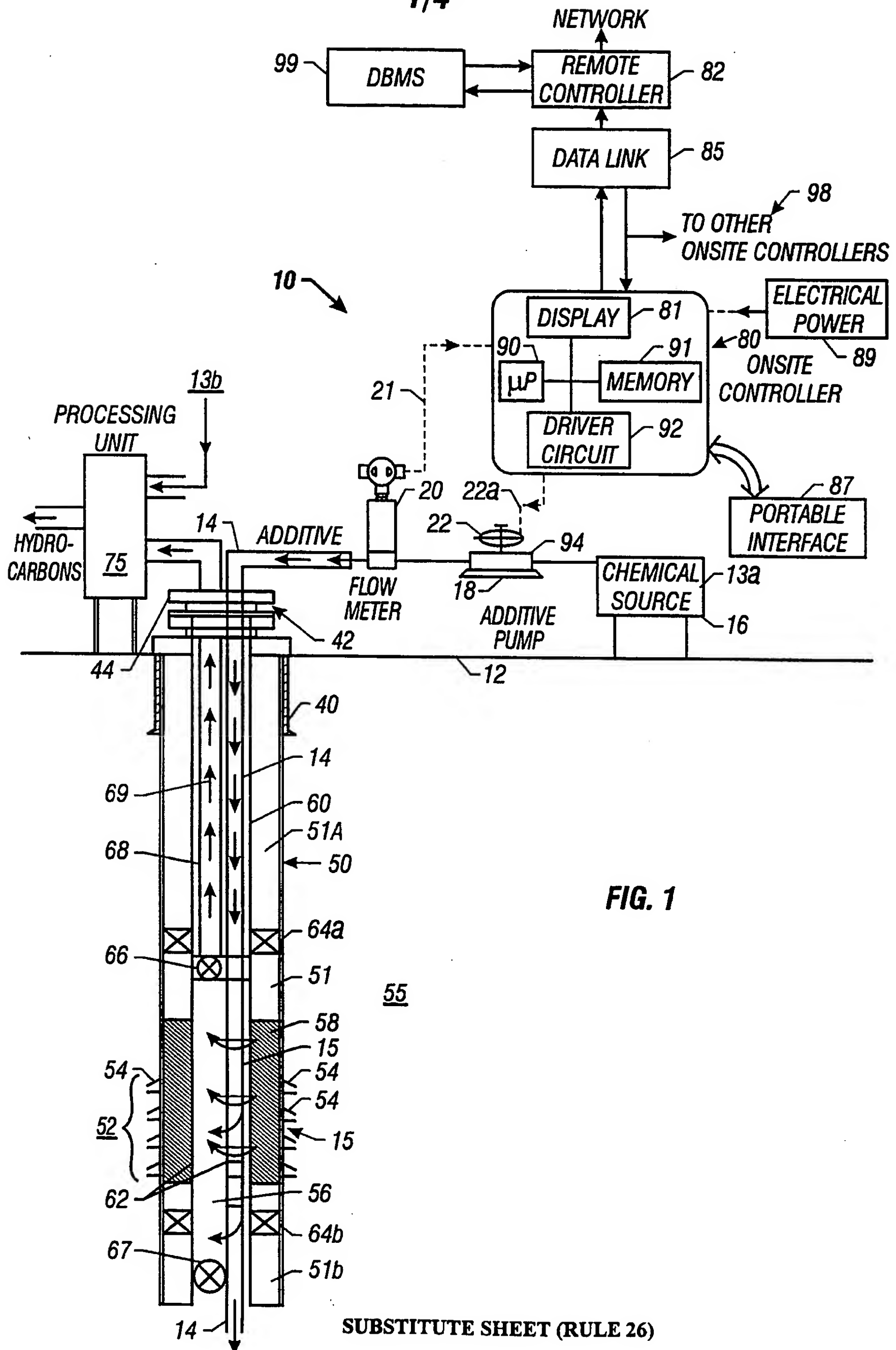
1 15. A method of monitoring at a wellsite supply of additives to
2 formation fluid recovered through a wellbore and controlling said supply
3 from a remote location, said method comprising:

- 4 (a) controlling the flow rate of the supply of a selected additive
5 from a source thereof at the wellsite into said formation
6 fluid via a supply line;
- 7 (b) measuring a parameter indicative of the flow rate of the
8 additive supplied to said formation fluid and generating a
9 signal indicative of said flow rate;
- 10 (c) receiving at the wellsite the signal indicative of the flow rate
11 and transmitting a signal representative of the flow rate to
12 the remote location; and
- 13 (d) receiving at said remote location signals transmitted from
14 the wellsite and in response thereto transmitting command
15 signals to the wellsite representative of a desired change in
16 the flow rate of the additive supplied; and
- 17 (e) controlling the flow rate of the supply of the additive in
18 response to the command signals

1 16. The method of claim 15 further comprising displaying at the well
2 site the flow rate of the additive supplied to the formation fluid.

1 17. The method of claim 16 further comprising a manual override of
2 controlling the flow rate of the supply of the additive by performing a
3 function selected from (i) setting a flow rate of the additive, (ii) setting a
4 range of allowable values for the flow rate of the additive, and (iii) a
5 combinations thereof.

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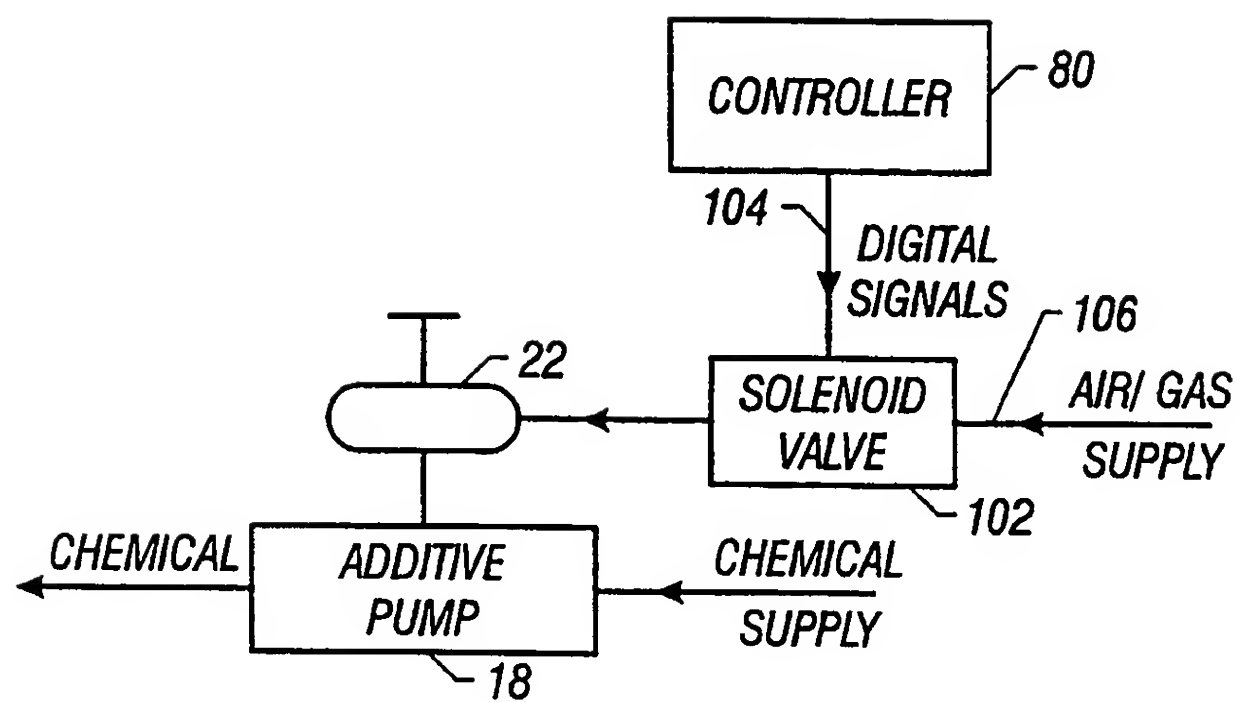


FIG. 1A

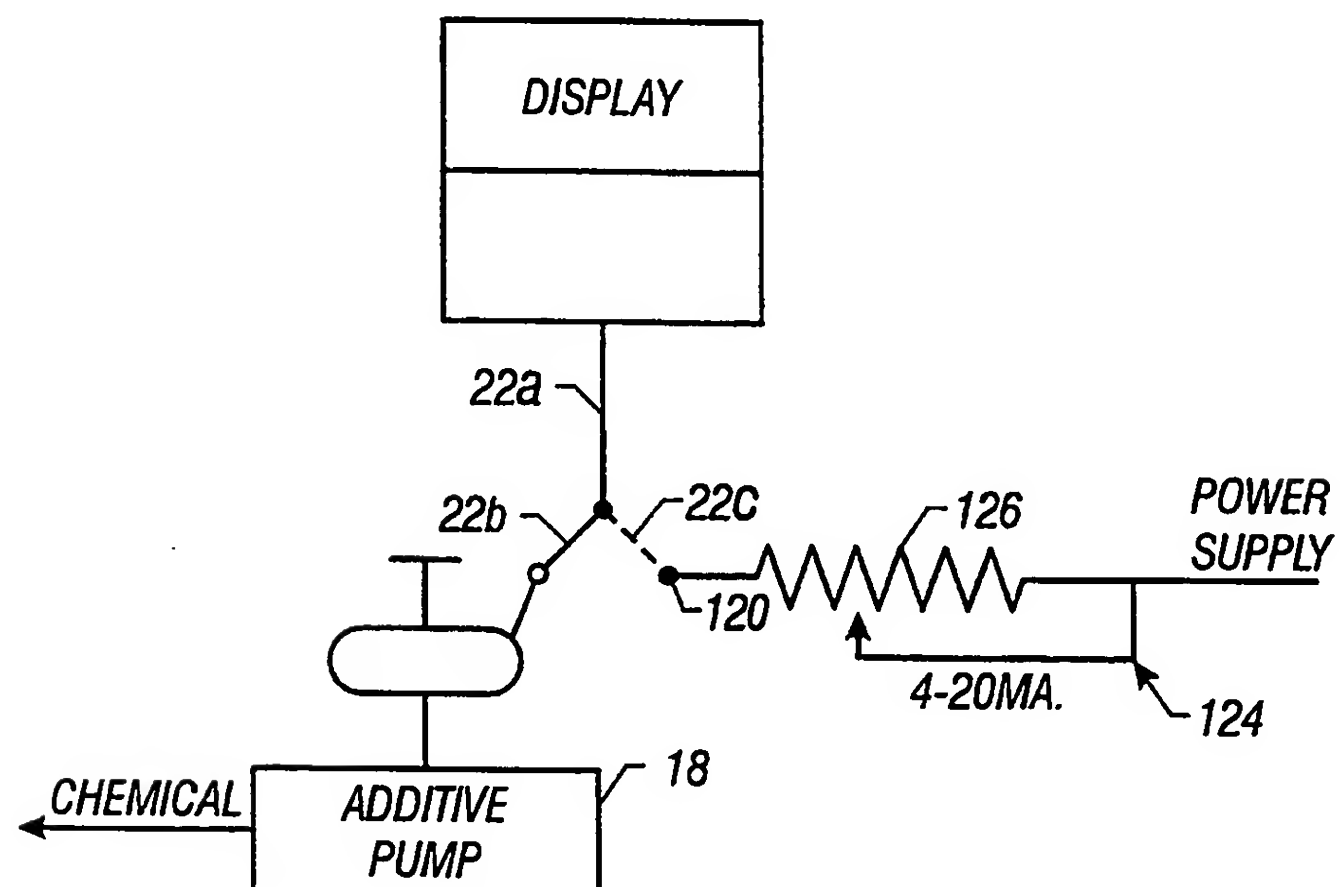


FIG. 1B

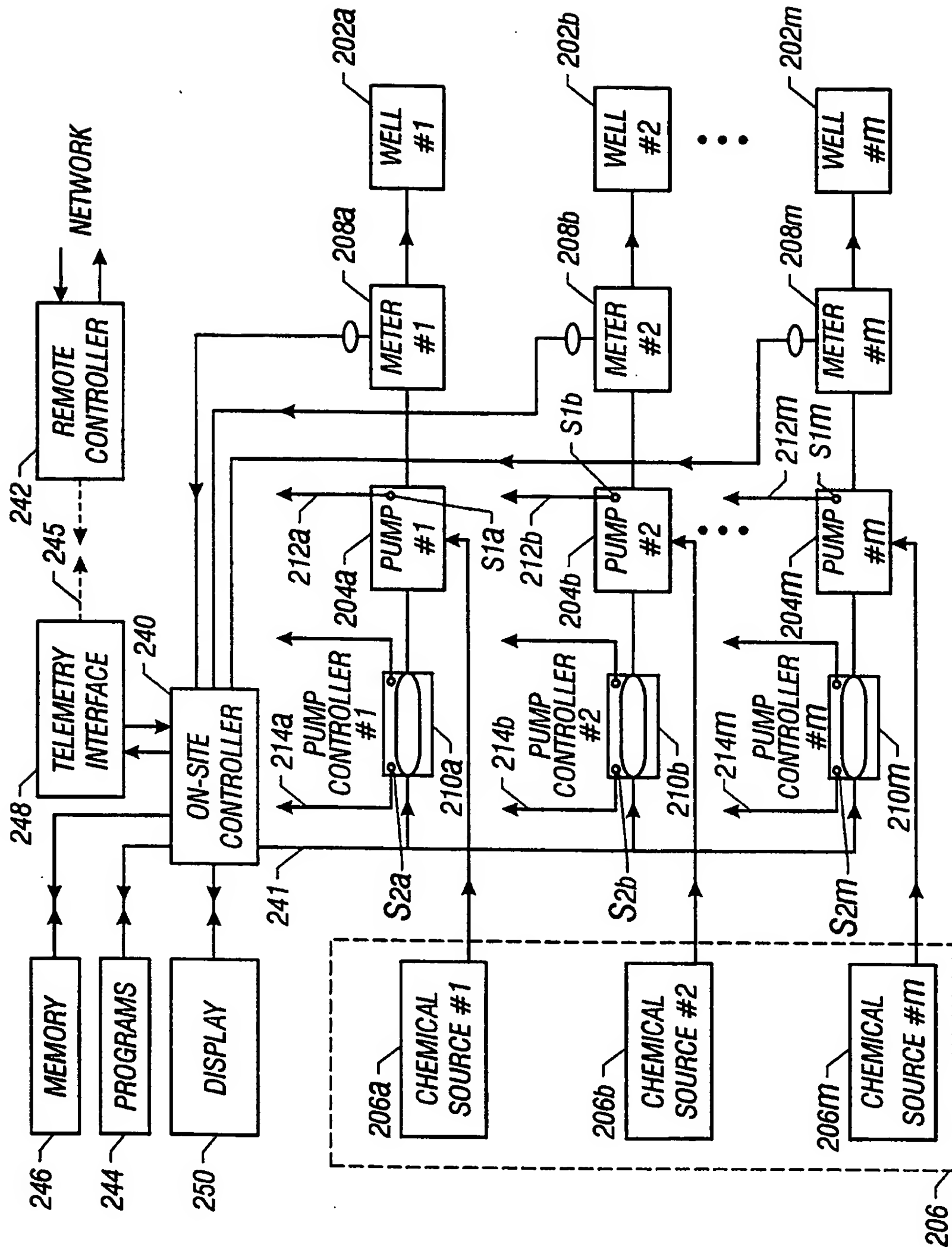
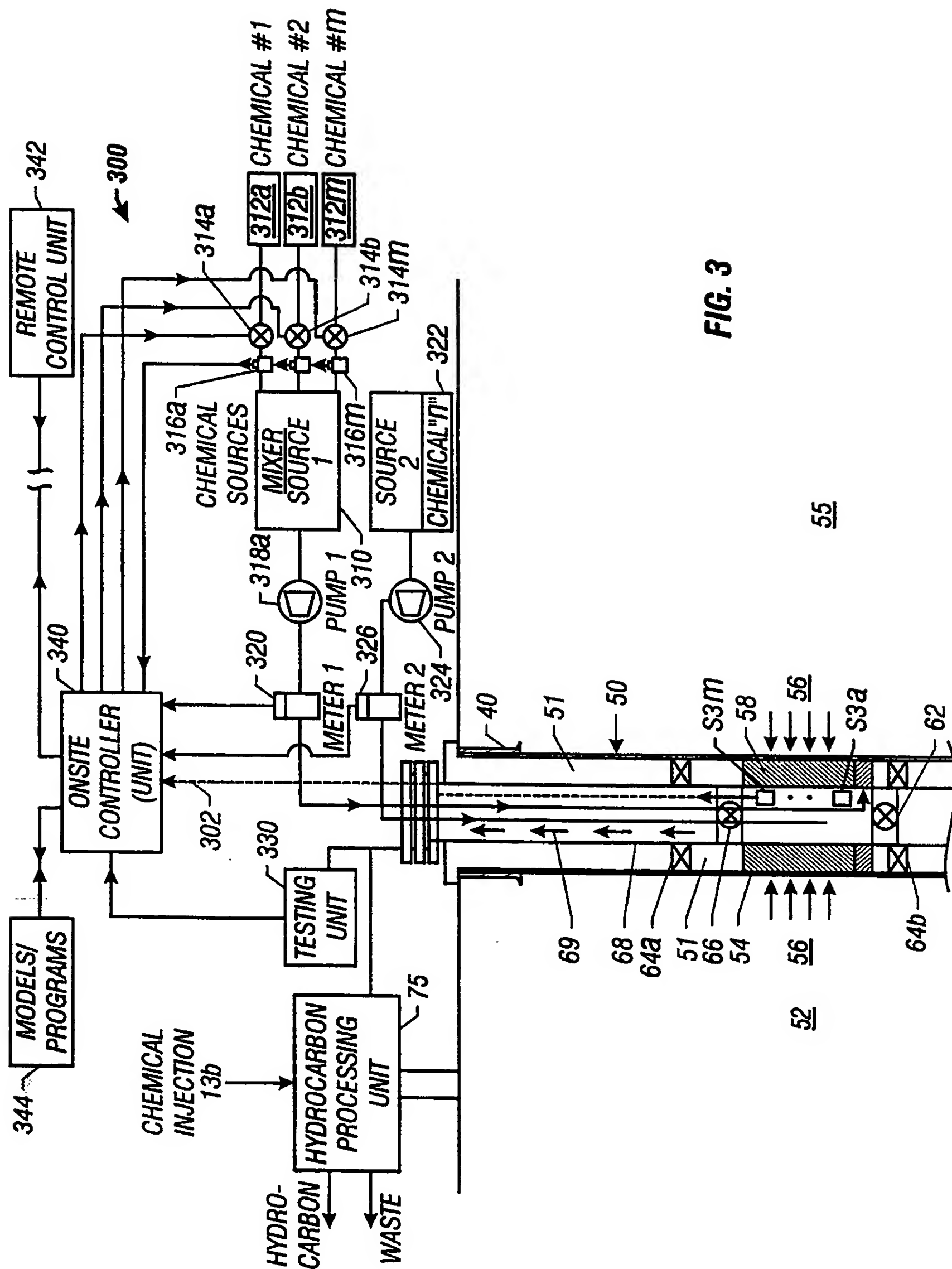


FIG. 2

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/30448

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B37/06 E21B41/02 E21B43/25

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

14 March 2000

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

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PCT/US 99/30448

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